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Overview of Advanced Reactor Research Capabilities

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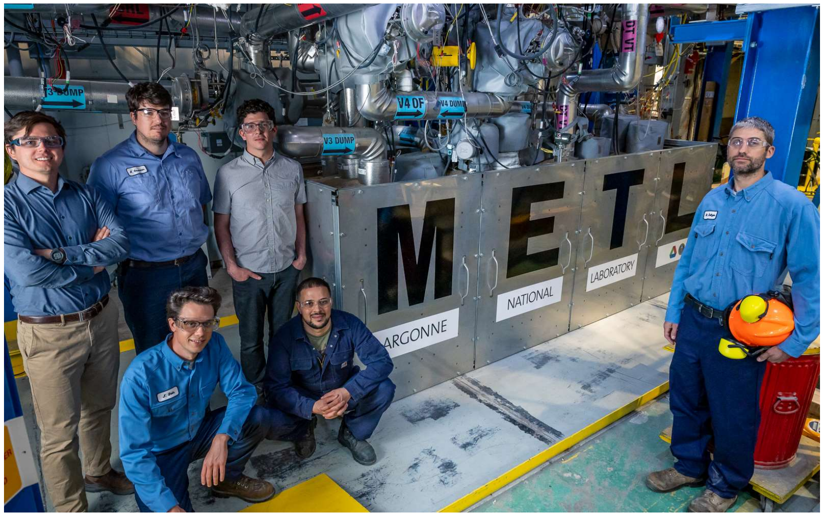
Mechanisms Engineering Test Loop (METL)

- **To test small or intermediate scale advanced liquid metal components and instrumentation in sodium and to train the next generation of engineers on sodium experiments**
- **METL consists of:**
  - ~3,000 kg of reactor-grade sodium – purified in cold trap
  - Two 18-inch and two 28-inch test vessels, four more vessels planned
  - Max system temperature = 537.8°C (1000°F) (except for 28-inch test vessels – 648.9°C (1200°F))
  - Test vessels can be isolated from main loop
- **The facility started operations in September 2018**
- **Test Articles:**
  - Gear Test Assembly (GTA) and Gripper Test Article (GrTA)
  - Thermal Hydraulic Experimental Test Article (THETA)
  - Flow Sensor Test Article (F-STAr)
- **See: https://www.anl.gov/nse/mechanisms-engineering-test-loop-facility**



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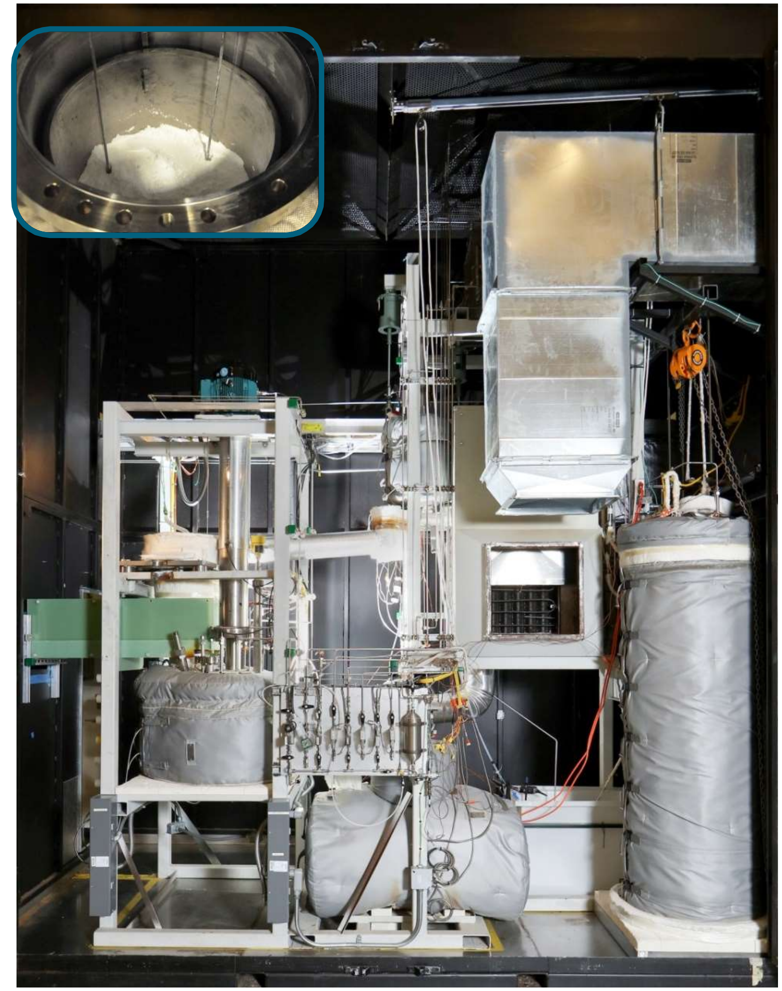
Liquid Salt Test Loop (LSTL)

Largest F salt loop in DOE

Salt	NaF-KF-LiF (FLiNaK)
Operating Temp.	700°C
Flow rate	≤4.5 kg/s (136 lpm)
Operating pressure	Near atmospheric
Primary Materials	Inconel 600
Loop volume	80 liters
Power	200 kW induction ~20 kW trace
Primary piping ID	2.67 cm (1.05 in.)
Initial operation	Summer 2016

Current Test Focus:
- Chemistry monitoring and control
- Species transport and off-gas monitoring
- Novel instrumentation testing
- Test data for SAM, MELCOR, and other tools

Example NEUP Collaborations:
- Coupon exposure
- New sensor testing and demonstration
- Modeling & Sim. comparisons
- Component characterization



Contact: Kevin Robb (ORNL), robbkr@ornl.gov

Facility to Alleviate Salt Technology Risks (FASTR)

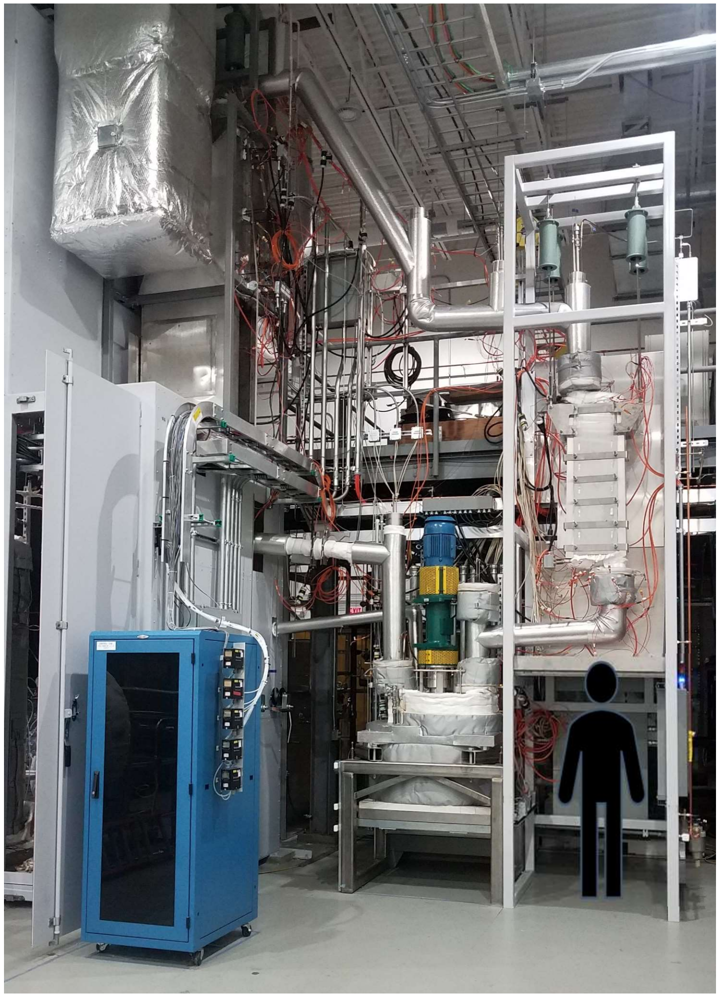
Largest Cl salt loop in DOE

Salt	NaCl-KCl-$MgCl_2$
Operating Temp.	725°C
Flow rate	≤7.0 kg/s (228 lpm)
Operating pressure	Near atmospheric
Primary Materials	C-276 & Inconel 600
Loop volume	154 liters
Power	400 kW Main Heater ~71 kW trace
Primary piping ID	5.20 cm (2.05 in.)
Initial operation	December 2022

Current Test Goals:
- Chemistry and corrosion control
- System thermal hydraulics
- Digit twin demonstration
- Extended/life testing

Example NEUP Collaborations:
- Coupon exposure
- New sensor testing and demonstration
- Modeling & Sim. Comparisons
- Salt purification approaches

Robb, Kevin, and Kappes, Ethan. *Facility to Alleviate Salt Technology Risks (FASTR): Commissioning Update*. United States: **ORNL/TM-2023/2846**, 2023. Web. doi:10.2172/1960689.
Robb, Kevin, Kappes, Ethan, and Mulligan, Padhraic L. *Facility to Alleviate Salt Technology Risks (FASTR): Design Report*. United States: **ORNL/TM-2022/2803**, 2022. Web. doi:10.2172/1906574.



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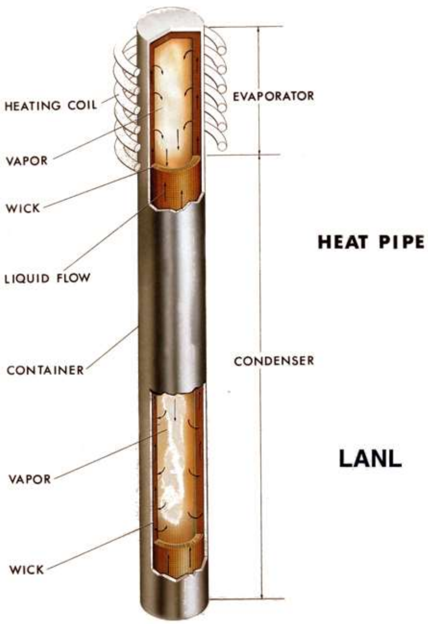
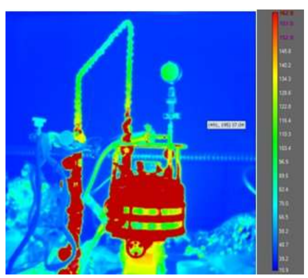
Heat Pipes and Filling Capability

- **Heat pipes are a heat transfer mechanism for microreactors that can remove heat from one part (the bottom) of the core to another quickly using a working material such as sodium.**
- **The eFill37 is a scalable heat pipe charging and sealing apparatus developed with the intent of easing and automating the manufacture of heat-pipe-cooled microreactors.**



LANL

eFill37 and metered fill process



Plug Loader

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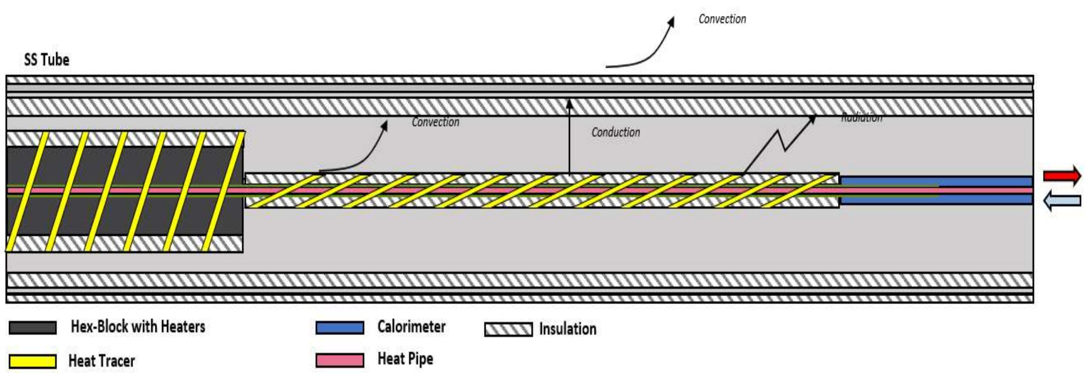
Single Primary Heat Extraction and Removal Emulator (SPHERE) SPHERE_Factsheet_MRP_May2022.pdf (inl.gov)

Provide capabilities to perform steady-state and transient testing of heat pipes and heat transfer:

- **Wide range of heating values and operating temperatures**
- **Observe heat pipe startup and transient operation**

Develop effective thermal coupling methods between the heat pipe outer surface and core structures

Measure heat pipe axial temperature profiles during startup, steady-state, and transient operation using thermal imaging and surface measurements



Parameter	Value
Length	10 ft
Diameter	12 in
Tube material	Stainless steel
Connections	Flanged for gas flow and instrumentation feedthrough
Maximum power	20 kW
Max temperature	900 C
Heat removal	Passive radiation or water-cooled gas gap calorimeter

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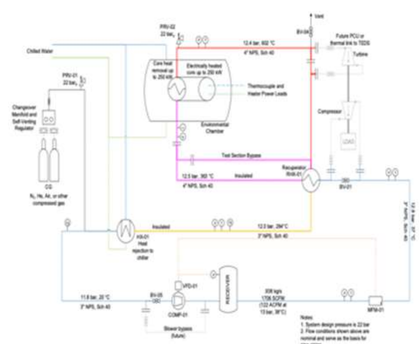
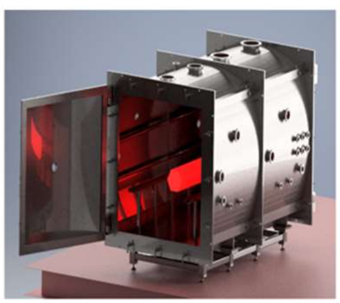
Microreactor AGile Non-nuclear Experimental Testbed (MAGNET)

- General purpose test bed for performance evaluation of microreactor design concepts (heat pipe, gas-cooled, other)
- Provide detailed reactor core and heat removal section thermal hydraulic performance data for prototypical geometries and operating conditions
- Demonstrate interface of heat removal section and core section
- Provides for integrated materials and instrumentation testing
- Co-located with integrated energy systems R&D capabilities

Parameter	Value
Chamber size	5 ft x 5 ft x 10 ft
Heat removal	Liquid-cooled chamber walls
Connections	Flanged for gas flow, instrumentation feedthroughs, and viewing windows
Coolants	Air, inert gas (He, N2)
Gas flow rates	Up to 43.7 ACFM at 290 psig
Design pressure	22 barg
Maximum power	250 kW
Max test article temperature	750°C
Heat removal	Passive radiation or forced gas cooling



a) MAGNET Process Flow Diagram



b) MAGNET Environmental Enclosure

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Helium Component Test Facility

- **Helium Component Test Facility (He-CTF) integrates with MAGNET infrastructure to provide additional testing capability for reactor developers**
  - Provides access to a facility used to validate component performance in a flowing or stagnant high-temperature, high-pressure, helium environment
  - Will reduce time and cost associated with demonstration of non-irradiated reactor components in a near-prototypic environment
  - Helium Operating Parameters: pressure up to 20 bar, flow up to 70 g/s, and temp up to 650 °C
  - INL collects pressure, temperature, and flow data during testing to help reactor developers analyze and understand component performance in helium environment
- **Significance:**
  - He-CTF gives INL capabilities to test component prototypes in a non-irradiated, high-temperature, high-pressure, helium environment
  - Helium test loops exist in the U.S., but none are of this scale

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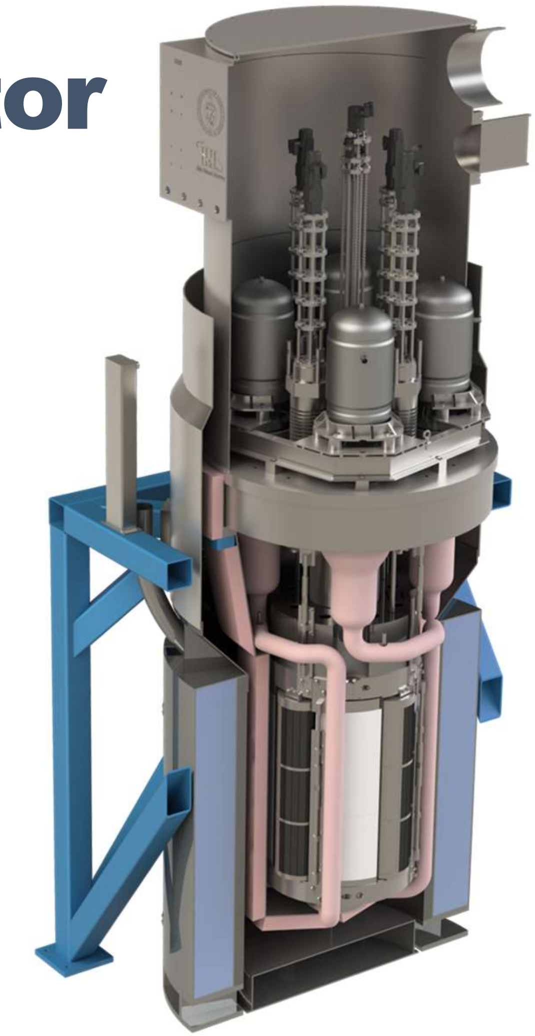
MARVEL - Test Microreactor

Microreactor Application Research, Validation and EvaLuation Project

Key Design Features	
Thermal Power	100 kW (85 kW nominal)
Electrical Power	20 kWe (QB80 Stirling Engines)
Weight	< 12 US ton
Primary Coolant	Sodium-Potassium eutectic
Intermediate Coolant	Lead
Coolant Driver	Natural Convection, single phase
Fuel	HALE(UZrH), 304SS clad, end caps
Moderator	Hydrogen
Neutron Reflector	Graphite, Beryllium (S200), Beryllium oxide
Reactivity Control	Radial Control Drums, Central Absorber
Primary Coolant Boundary	SS316H

Innovation- MARVEL used an inherently safe research reactor fuel and designed a high-temperature advanced reactor



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Virtual Test Bed (VTB)

- **The VTB supports NRIC's mission of delivering successful demonstration and deployment of advanced nuclear energy**

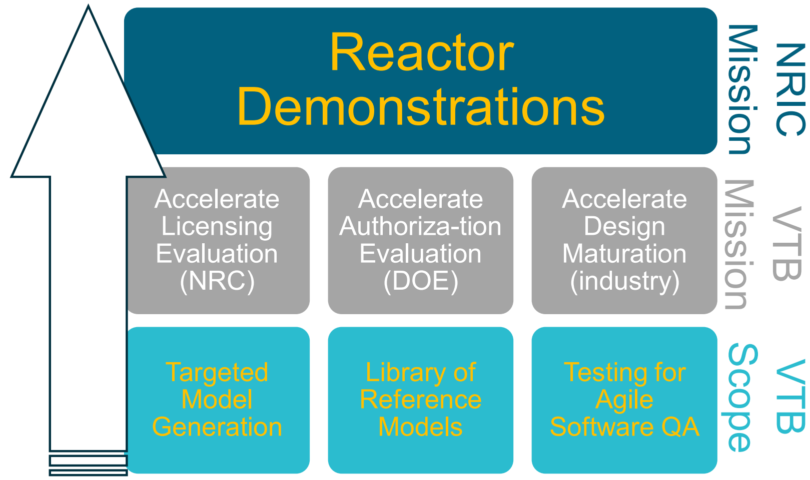
How?

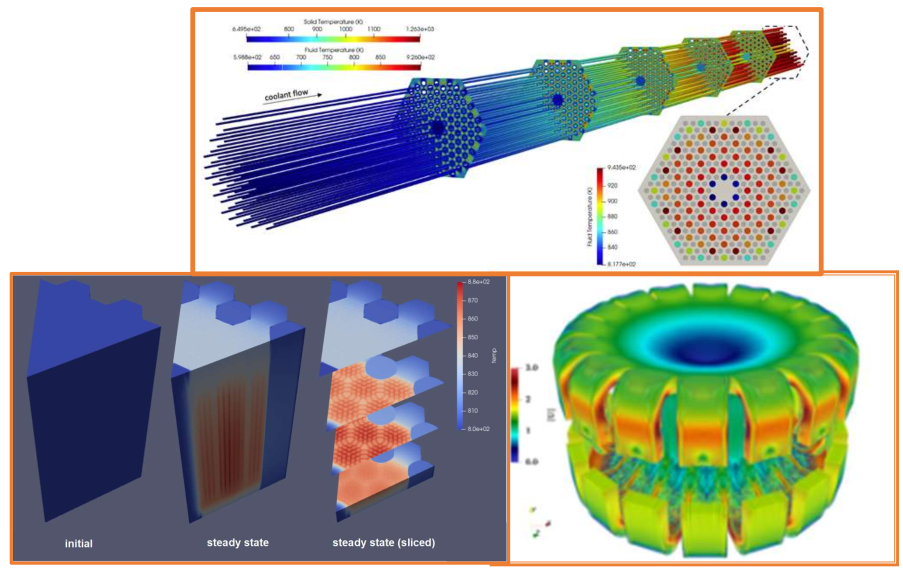
- **Library of Reference Model**: database of advanced multiphysics advanced reactor models that users can download, edit, and re-run
- **Targeted Model Generation**: developing demonstration-relevant models (e.g., candidates for DOME/LOTUS) to accelerate safety evaluations
- **Continuous Software QA**: linking repository to software development to avoid legacy issues while enabling rapid code development

VTB So Far

- 30+ models hosted (and counting): 14 reactor designs, and 7 codes showcased
- Collaboration with NEAMS, industry, NRC, and academia
- Help accelerate timelines for DOE/NRC confirmatory analysis
- Accelerate development cycle for industry and academia

VTB Link: https://mooseframework.inl.gov/virtual_test_bed
NRIC Tech Talk Link: https://nric.inl.gov/nric-tech-talks-modeling_simulation/





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Questions?